STABILITY AND THERMAL PROPERTIES OF HYDROXYL MULTIWALLED CARBON NANOTUBES IN DIFFERENT MEDIUM

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A thesis submitted
in fulfilment of the requirements for the degree of Master of Science
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DECLARATION

I declare that this thesis entitled "Stability and Thermal Properties of Hydroxyl Multiwalled Carbon Nanotubes in Different Medium" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : ....

Date : ....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Mechanical Engineering.

Signature	:	....
Supervisor Name	:	....
Date	:	....

DEDICATION

To Allah s.w.t, Alhamdulillah for your blessings.

To my beloved Emak, Abah, Adik, Anis, Tok, Tokwan and Yayang.

Thank you for your love, understand and support.

May Allah grant us a forever Jannah.

To supervisor,

Thank you for your support, knowledges, guidance, and patience.

May Allah grant you goodness and blessings.

ABSTRACT

Nanotechnology has introduce nanofluids as suspension of nanoparticles in the base fluids. The nanoparticles dispersion in fluids due to thermal properties limitation. Hence, inclusion of MWCNT-OH nanoparticles and PVP in base fluids could enhance the thermal properties and the nanofluids stability. Futhermore, the low boiling point and high freezing point of deionized water has causes another problem and be solve by mixed this fluid with ethylene glycol which act as antifreeze fluid. Intention of this research are to investigate the nanofluid dispersion and stability and as well as thermal properties performance. The two-step method is used in formulazation of nanofluid on concentration 0.1 wt% to 1.0 wt% of MWCNT-OH and base fluid deionized water to ethylene glycol ratio is 0:100%, 100:0%, 90:10%, 80:20%, 70:30%, 60:40% and 50:50%. The dispersion process has selected 5 minutes dispersion process as the optimum time in getting better dispersion and stability of nanofluids. The nanofluids has been tested at 6°C, 25°C and 40°C in thermal conductivity and heat transfer coefficient test. In thermal conductivity test, addition of MWCNT-OH in deionized water is the highest thermal conductivity enhancement which 21.21% (0.4 wt%) at 40°C. However, the thermal conductivity decrement also happens on deionized water based nanofluids at range concentration 0.3 wt% and 0.5 wt% till 1.0 wt% at 40°C. Moreover, the thermal conductivity results is fluctuated or inconsistent with increment of temperature and concentration. Hence, it mean thermal conductivity is independent on temperature and concentration. Meanwhile, heat transfer coefficient is increases with increment of temperature and nanoparticles concentration. The highest enhancement of heat transfer coefficient is occurs on ratio 70:30;DI:EG which has 104.3% at 40°C and 1.0 wt%. The overall increment of heat transfer coefficient occurs on 1.0 wt% and 40°C. Only on 0:100; DI:EG, and 60:40; DI EG has the highest enhancement on 25°C. Besides, ethylene glycol based nanofluids has high heat transfer coefficient on 6°C.In specific heat test, addition of MWCNT-OH has decreased the specific heat exclude on 0.8 wt% of ethylene glycol based nanofluids. This test is conducted in room temperature. Based on these results, concentration, nanoparticles properties and coagulation in nanofluids causes specific heat decrement. Whilst, surface energy, nanoparticles size and area are contributed in high specific heat. To sum up, seeding of MWCNT-OH in fluids has enhanced the thermal properties on certain concentration and temperature.

ABSTRAK

Teknologi nano telah memperkenalkan bendalir nano sebagai dispersi partikel nano ke dalam bendalir konvensional. Ini disebabkan bendalir konvensional mempunyai keupayaan yang terhad dari segi sifat-sifat termal. Oleh demikian, penggunaan partikel MWCNT-OH dan PVP ke dalam bendalir dipercayai dapat meningkatkan sifat-sifat termal dan kestabilan bendalir nano. Tambahan lagi, masalah takat didih yang rendah dan takat beku yang tinggi pada air ternyahion dapat ditangini dengan menggunakan bendalir antibeku seperti etilena glikol. Tujuan kajian ini adalah untuk menyiasat dispersi dan kestabilan bendalir nano dan juga prestasi sifat-sifat termal bendalir nano. Kaedah dua langkah telah digunakan dalam penghasilan bendalir nano pada kepekatan MWCNT-OH dari 0.1 wt% hingga 1.0 wt% dan nisbah bendalir asas pada 0:100%, 100:0%, 90:10%, 80:20%, 70:30%, 60:40% dan 50:50%. Proses dispersi telah memilih 5 minit waktu proses dispersi sebagai masa terbaik dalam penghasilan bendalir nano yang stabil. Bendalir nano telah diuji pada tiga suhu yang berbeza iaitu 6°C, 25°C and 40°C pada ujian kekonduksian termal dan ujian kecekapan pemindahan haba. Dalam ujian kekonduksian termal, penambahan MWCNT-OH dalam air ternyahion mempunyai peningkatan kekonduksian termal paling tertinggi iaitu 21.21% (0.4 wt%) pada suhu 40°C. Namun, penurunan kekonduksian termal turut berlaku pada bendalir nano air ternyahion pada kepekatan 0.3 wt% dan 0.5 wt% hingga 1.0 wt% pada suhu 40°C. Tambahan lagi, hasil kekonduksian termal adalah tidak konsisten dengan peningkatan suhu dan kepekatan. Oleh yang demikian, ini bermakna kekonduksian termal tidak bergantung pada suhu dan kepekatan. Manakala, hasil kecekapan pemindahan haba meningkat dengan meningkatnya suhu dan kepekatan partikel nano. Peningkatan tertinggi kecekapan pemindahan haba iaitu 104.3% berlaku di nisbah 70:30;DI;EG pada suhu 40°C dan 1.0 wt%. Peningkatan kecekapan pemindahan haba keseluruhannya berlaku pada 1.0 wt% dan suhu 40°C. Hanya 0:100; DI:EG, dan 60:40; DI EG mempunyai peningkatan kecekapan pemindahan haba tertinggi pada suhu 25°C dan etilena glikol bendalir nano pada suhu 6°C. Di dalam ujian haba tentu yang dilakukan dalam suhu bilik menunjukkan penurun haba tentu pada setiap bendalir nano kecuali pada 0.8wt% etilena glikol bendalir nano. Analisis mendapati kepekatan partikel, sifat partikel nano dan mendapan dalam bendalir nano merupakan faktor penurunan haba tentu. Walau bagaimanapun, tenaga permukaan, saiz partikel dan kawasan permukaan partikel menyumbang kepada peningkatan haba tentu. Natijahnya, penambahan partikel MWCNT-OH dalam bendalir dapat meningkatkan sifat-sifat termal pada kepekatan dan suhu tertentu sahaja.

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LIST OF ABBREVIATIONS AND SYMBOLS

CNT	-	Carbon nanotubes
CPU	-	Central processing unit
MWCNT	-	Multiwalled carbon nanotube
-OH	-	Hydroxyl
FTIR	-	Fourier transformation infrared spectra
HRTEM	-	High resolution transmission electron microscopy
TEM	-	Transmission electron microscope
SEM	-	Scanning electron microscopy
SWCNT	-	Single walled carbon nanotubes
SANSS	-	Submerged arc nanoparticle synthesis system
PVP	-	Polyvinylpyrrolidone
Cu	-	Copper
CuO	-	Copper oxide
Al_2O_3	-	Aluminium oxide
$CuSO_4.5H_2O$	-	Copper (II) sulfate pentahydrate
FePt	-	Iron platinum
UV	-	Ultraviolet
HLB	-	Hydrophilic or lipophilic balance
SDS	-	Sodium dedocyl sulphate
SDBS	-	Sodium dodecylbenzene sulfonate
CTAB	-	Hexadecyltrimethyl ammonium bromide
GA	-	Gum Arabic

CTAC	-	Cetyltrimethylammoniumchloride
SiO_2	-	Silica dioxide
TiO_2	-	Titanium dioxide
rpm	-	Revolutions per minute
mV	-	Millivolts
Au-NPs	-	Gold nanoparticles
DWCNT	-	Double walled carbon nanotube
PMAA	-	Polymethacryclic acid
ZnO	-	Zinc oxide
DVLO	-	Derjaguin, Verway, Landau and Overbeek
Btu	-	British thermal unit
MEMS	-	Microelectromechanical systems
EWOD	-	Electrowetting on dielectric
$Cu\text{-}H_2O$	-	Copper monohydrate
K	-	Thermal conductivity
K	-	Kelvin
Al_2O_3	-	Alumina
EG	-	Ethylene glycol
EO	-	Engine oil
DI	-	Deionized water
Re	-	Reynolds number
NaOH	-	Sodium hydroxide
HNO_3	-	Nitric acid
STR	-	Stability test rig
HVAC	-	Heating, ventilation and air conditioning

ASHRAE	-	American society of heating, refrigerating and air-conditioning Engineers
CE	-	Certification mark
Q	-	Flow of heat
h	-	Coefficient of heat transfer
A	-	Heat transfer area
ΔT	-	Temperature different
m	-	Mass of water bath
C_p	-	Specific heat of the water bath
K	-	Temperature difference in the water bath
Nu	-	Nusselt number
D	-	Copper pipe diameter
k	-	Thermal conductivity
T_{ln}	-	Logarithmic mean temperature
T_{in}	-	Temperature inlet
T_{out}	-	Temperature outlet
T_{wb}		Temperature of water bath
T_s		Temperature of surface
T_e		Temperature exit
ID		Inside diameter
OD		Outside diameter

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